"Shirase" navigation data analysis to improve future ice operation and icebreaker design

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The main Japanese Antarctic research base "Syowa Station" is located in Lützow-Holm Bay (LHB), which is often covered with thick multi-year landfast ice. Navigating through such heavy ice requires very long time and much fuel, and we have encountered twice that the Japanese Antarctic research icebreaker "Shirase (II)" could not even reach Syowa Station since 2009. The studies have been conducted to improve the efficiency of navigation in heavy ice area. Especially there have been many researches focusing on hull form design or other equipment technologies such as snow lubrication system. In this paper, we focus on ship operations such as pathway selection and ramming method.

In 2017/2018 season, we were able to navigate widely in LHB and obtain a large amount of navigation data with relatively light ice condition. Firstly, ramming method is investigated in detail by ship data analysis, interview with ship crew, and field experiment. Ship GPS data during ramming is shown in Fig. 1, which shows clear difference of track depending on ramming method. The ramming methods are roughly classified to discuss the efficiency of each method. Secondly, we investigated the operations when "Shirase" made a 180-degrees turn with ramming in the areas of two different ice conditions. Fig.2 shows one of the turns, which suggests that almost all the ramming points are on a circle (which means the steering performance does not vary among each ram) and its diameter is approximately 1400m. This steering performance with ramming is compared with that of continuous icebreaking mode. The effect of ice condition on steering performance is also investigated.

Thirdly, we investigate the case that "Shirase" faced choice between direct route with heavy ice and detour with light ice condition. The required time of the actual route and of the other are calculated and compared to estimate the potentially savable time by pathway selection. Furthermore, it is attempted to predict required time of each route by using ice thickness distribution data which was obtained beforehand by helicopter-borne Electro-Magnetic sensor.

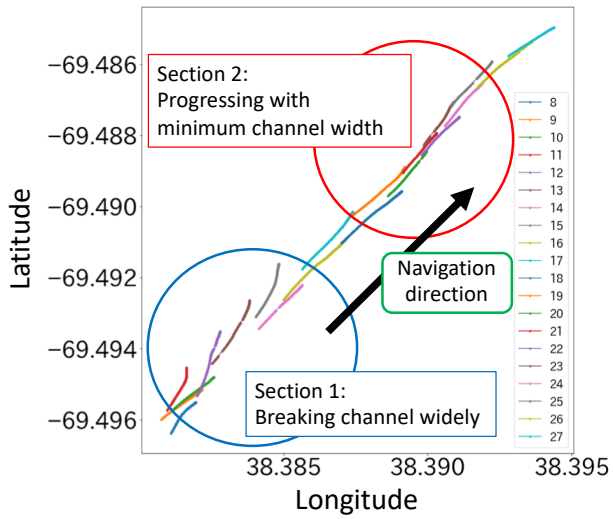

Figure 1. Ship tracks of 8th -27th ramming on 29 Jan
In section 2 the operator followed a planned procedure, while in section 1 no methods were specified

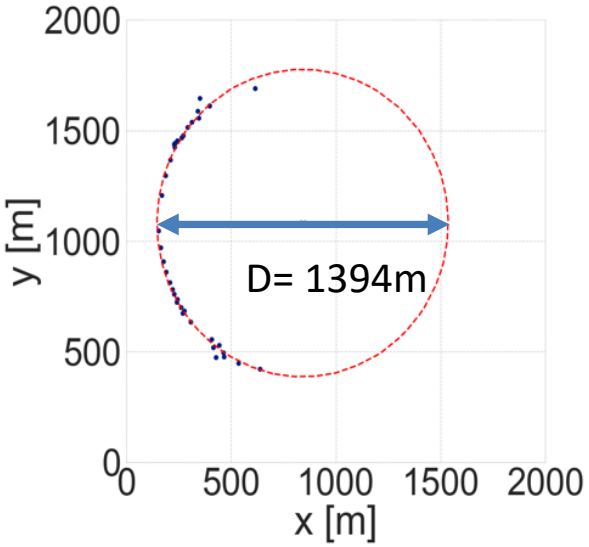

Figure 2. Shirase's ramming turn on 30 Jan
D is the estimated turning diameter

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